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Microsurgical subinguinal varicocelectomy with spermatic cord double traction and vein stripping

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We retrospectively reviewed data for 286 patients with varicocele who underwent microsurgical subinguinal varicocelectomy from March 2015 to May 2017 in Shanghai General Hospital (Shanghai, China). In this surgical approach, the testis was delivered, and the gubernacular and external cremasteric veins were stripped. In addition, the spermatic cord was delivered downward with continuous double traction away from the external ring. The remaining procedure was similar to the conventional approach. We followed patients for at least 3 months and evaluated postoperative semen parameters, pain symptoms, and complications. We excluded data for 32 men due to inadequate follow-up (<3 months). Of the remaining 254 patients, 73 had oligoasthenospermia, 121 had nonobstructive azoospermia, and 60 had symptomatic varicoceles. Total progressive sperm counts increased in the oligoasthenospermic patients from a median preoperative value of $9.15 \times 10^6 \text{ ml}^{-1}$ to $25.33 \times 10^6 \text{ ml}^{-1}$ ($n = 34$), and 35.6% (26/73) initially oligoasthenospermic men contributed to unassisted pregnancies. Sperm returned to the ejaculate in 12.4% (15/121) azoospermia patients. In patients with scrotal pain ($n = 60$), 43 (71.7%) reported complete resolution of pain, 16 (26.7%) reported partial resolution, and 1 (1.7%) reported no change. No patients experienced varicocele recurrence. This double-traction strategy avoids opening the external oblique aponeurosis, and results in less damage and faster recovery. In addition, the stripping strategy eliminates potential damage to the testis caused by the varicose veins. Our results showed that microsurgical subinguinal varicocelectomy using spermatic cord double traction in conjunction with testicular delivery for vein stripping is a safe and effective approach for varicocele repair.

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Keywords: azoospermia; low sperm count; sperm motility; spermatic cord; varicocele

INTRODUCTION

A varicocele is defined as abnormal dilation of the pampiniform plexus in the scrotum, detected in approximately 15% of the general male population.¹ Studies show that varicocele accounts for 40% of primary male infertility and 71% of secondary male infertility,² of which approximately 4.3%–13.3% are secondary to nonobstructive azoospermia (NOA).³ In addition, the estimated prevalence of scrotal pain in men with varicocele is up to 10%.⁴

Varicocelectomy is beneficial to men with infertility and can eliminate scrotal pain that is secondary to clinical varicoceles.^{1,5,6} A variety of surgical approaches have been adopted for varicocele treatment, including open nonmicrosurgical, laparoscopic, or microsurgical varicocelectomy.⁷ Compared with other approaches, microsurgical varicocelectomy decreases the risk of complications, namely recurrence, hydrocele formation, and arterial injury. Therefore, this microsurgical technique has become the most widely recommended approach.^{1,7,8}

Microsurgical varicocelectomy can be performed by either inguinal or subinguinal approaches, with or without testicular delivery.^{6,8–10} The incidence of postoperative pain is higher with the inguinal approach

because the external oblique aponeurosis is incised; however, this approach involves simpler venous anatomy.¹¹ In the subinguinal technique, there is less pain at the expense of a higher number of veins to ligate.^{12,13} Testicular delivery provides access to the external and gubernacular veins. Previous reports have suggested that microsurgical subinguinal varicocelectomy (MSV) with testicular delivery markedly decreases the incidence of recurrence and postoperative hydrocele.^{8,9} However, others reported that MSV without testicular delivery had equivalent or more beneficial effects regarding semen quality, without affecting the recurrence rate.^{10,14} We believe that the visual component of Grade III varicoceles results primarily from dilated external cremaster and gubernacular veins. Furthermore, we speculate that varicocele, like other chronic vascular diseases (*e.g.*, lower limb varicose veins),¹⁵ not only leads to high temperature and reflux toxic metabolites but also damages the testes directly from the varicose veins via elevated oxidative stress levels in the spermatic venous wall.

Based on these issues, we hypothesized whether there is an approach that could eliminate the pathogenic risk factors to the greatest extent, with minimal complications. Therefore, we developed a combined MSV and spermatic cord double-traction and varicose

gubernacular and external vein stripping strategy (MSV-STVS). In this approach, the spermatic cord is double-retracted downward away from the external ring, which allows the surgeon to address the cord more proximally where less veins are encountered while leaving the external ring intact. In addition, the testis is delivered, and the gubernacular and external cremasteric veins are stripped, eliminating damage from the varicose veins. In this study, we retrospectively evaluated the safety and efficacy of MSV-STVS.

PATIENTS AND METHODS

Patients

A total of 286 patients with varicocele underwent MSV-STVS from March 2015 to May 2017 at Shanghai General Hospital (Shanghai, China). Varicocele was diagnosed and classified into Grades I–III during examination while the patients were in a standing position. Doppler ultrasonography was performed to confirm the diagnosis. Semen analysis was performed for patients according to the 2010 WHO criteria (WHO laboratory manual for the examination and processing of human semen). Oligoasthenospermia was defined by abnormal sperm counts ($<15 \times 10^6 \text{ ml}^{-1}$) and/or progressive motility $<32\%$. Azoospermia was defined as the complete absence of sperm in the centrifuged ejaculate samples in at least three semen analyses. Patients with reproductive congenital diseases or other diseases including cancer or other causes of scrotal pain such as testicular trauma, epididymitis, or prostatitis were excluded from this study. Patients with recurrent varicocele and a history of inguinal surgery were also excluded. Patients whose female partners with abnormal karyotypes and sexual hormone levels, abnormal fallopian tubal patency, or with a history of abortion were excluded. Patients' categorized clinical characteristics are listed in **Table 1**. Semen analyses were obtained at least 3 months postoperatively, and we graded patients with scrotal pain by their postoperative responses as complete response (pain was absent), partial response (pain persisted but was reduced), and no response (pain remained unchanged). Postoperative complications such as hematoma, wound infection, scrotal edema, recurrence, and testicular atrophy were recorded. The study was approved by the Ethics Committee of Shanghai General Hospital. The requirement for informed consent was waived because of the study's retrospective design.

Surgical technique

MSV-STVS was performed under general anesthesia. An incision was made at the external inguinal ring, and the spermatic cord was visualized under the external inguinal ring after Camper's fascia and Scarpa's fascia were opened. The cord was then grasped with a Babcock clamp

and elevated out of the incision. After encircling the cord with a rubber drainage tube, we bluntly dissected the cord to its proximal end using a finger. The testis was then delivered through the incision, and the gubernacular veins and external spermatic veins were isolated, stripped, and ligated using 4-0 silk suture, titanium clips, or electrocautery. The testis was then returned to the scrotum. The cord was delivered away from the external ring and fixed using a 20-F rubber surgical drain (ShiDa, Zhanjiang, China) with continuous traction. Zeiss surgical microscope (Vario 700; Carl Zeiss Meditec AG, Jena, Germany) was brought into the surgical field, and the microsurgical procedure was performed using $\times 8$ to $\times 15$ power magnification. The external and internal spermatic fasciae were opened first, and then, the vas deferens and associated vasculature were isolated and preserved under a plastic strip. Next, we used another rubber band to retract the isolated cord downward and adjusted tension to ensure arterial flow, judged by a micro-Doppler (VTI Doppler, Nashua, NH, USA). All identified arteries and lymphatics were dissected and preserved, and the internal spermatic veins were double-ligated with clips or 4-0 silk suture and divided. At the completion of the microsurgical procedure, the spermatic fasciae were closed with a 4-0 monofilament absorbable suture. After returning the spermatic cord, the incision was closed by suturing in layers with 4-0 absorbable suture. The main procedure is shown in **Figure 1** and **2**.

Statistics

Data with a Gaussian distribution were presented as mean \pm standard deviation (s.d.), and statistical analyses were performed using two-tailed Student's *t*-tests. Nonnormally distributed data were presented as median (P25, P75), and statistical analyses were performed using nonparametric tests. For comparisons between pre- and post-operative parameters in the same group, we used a paired experimental design. We used the Chi-square test to compare the rates. All analyses were performed using the SPSS (IBM Corp., Armonk, NY, USA), and $P < 0.05$ was considered statistically significant.

RESULTS

Number of vessels

An average of 11.91 veins was found on patients' left side and 11.60 veins on the right side. More specific data for the vessels are shown in **Table 2**.

Postoperative outcomes

In the oligoasthenospermic group, we analyzed 43 patients' semen during the follow-up. Sperm concentration, progressive motility, and total progressive sperm motility improved after surgery (**Table 3**). A total of 73 patients, including the 43 patients with oligoasthenospermia,

Table 1: Patients' preoperative demographics

Characteristic	Total	OAS	NOA	SP
Patients, <i>n</i> (%)	286	92 (32.2)	131 (45.8)	63 (22.0)
Age (year), mean \pm s.d. (range)	29.23 \pm 5.61 (18–50)	30.39 \pm 4.68 (21–41)	30.07 \pm 4.72 (21–43)	27.05 \pm 6.96 (18–50)
Duration (month), median (P25, P75)	24 (12, 36)	24 (12, 36)	24 (12, 36)	12 (6, 36)
MSV-STVS (<i>n</i>)	345	110	157	78
Laterality, <i>n</i> /total (%)				
Left only	221/286 (77.2)	70/92 (76.1)	104/131 (79.4)	47/63 (74.6)
Right only	2/286 (0.7)	0/92 (0)	1/131 (0.8)	1/63 (1.6)
Bilateral	63/286 (22.0)	22/92 (23.9)	26/131 (19.8)	15/63 (23.9)
Grade, <i>n</i> /total (%)				
Grade 1	9/345 (2.6)	0/110 (0)	6/157 (3.8)	3/78 (3.8)
Grade 2	212/345 (61.4)	64/110 (58.2)	109/157 (69.4)	39/78 (50.0)
Grade 3	124/345 (35.9)	46/110 (41.9)	42/157 (26.8)	36/78 (46.2)

OAS: oligoasthenospermia; NOA: nonobstructive azoospermia; SP: symptomatic varicocele; s.d.: standard deviation; MSV-STVS: microsurgical subinguinal varicocelectomy and spermatic cord double-traction and varicose gubernacular and external vein stripping strategy



were followed regarding subsequent pregnancies; 26 (35.6%) achieved natural pregnancies.

In the NOA patients, we followed 121 (92.4%, 121/131) patients, and motile sperm recovery occurred in 15 (12.4%, 15/121) patients. In the subset of 107 patients with failed sperm retrieval in ejaculates, 25 patients underwent microdissection testicular sperm extraction (micro-TESE), and three (12.0%, 3/25) successfully achieved sperm retrieval. Of the 15 patients with sperm recovery in ejaculates, five (33.3%) achieved natural pregnancies; four (26.7%) fathered babies via intracytoplasmic sperm injection (ICSI), whereas the remaining six patients (40.0%) underwent unsuccessful ICSI. Of the three patients with sperm retrieval during micro-TESE, two successfully underwent ICSI. The main postoperative patient outcomes are summarized in **Table 4**.

We followed 60 (95.2%, 60/63) patients suffering from scrotal pain; 43 patients (71.7%, 43/60) reported complete resolution of pain, 16 (26.7%, 16/60) reported partial resolution, and 1 patient (1.7%, 1/60) reported no change. The total improvement rate was 98.3%.

Regarding postoperative complications, one patient experienced hematoma (1/286, 0.3%) in the oligoasthenospermic group, and two patients experienced wound infection (2/286, 0.7%) in the NOA group. No scrotal edema, recurrence, or testicular atrophy occurred during the follow-up.

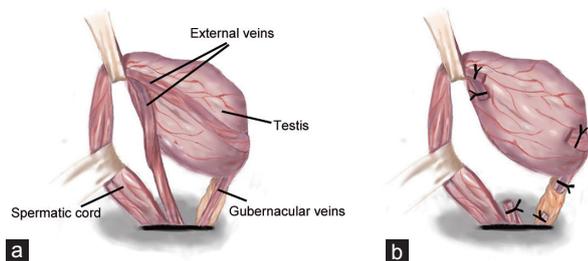


Figure 1: Gubernacular and external spermatic veins are stripped. (a) The testis is delivered out of the incision, and the gubernacular and external spermatic veins are clearly visible. (b) Gubernacular and external spermatic veins are ligated and stripped.

DISCUSSION

MSV is considered an optimal surgical approach for varicocele repair because it provides good relief with low complication rates.^{1,6,7,16} In this study, we described our experience performing MSV-STVS in 286 patients with varicocele. With this approach, sperm quality increased in some men with infertility, and pain was relieved in most patients with scrotal pain. In addition, complication rates were low without injury to the testicular arteries.

MSV-STVS has the following advantages. First, this technique is relatively easy to perform. The primary disadvantage of an inguinal approach is the need to incise the external oblique aponeurosis, which results in longer recovery.^{4,11} The disadvantage of the subinguinal approach is the need to ligate a higher number of veins and the greater potential for arterial injury because the testicular arteries are

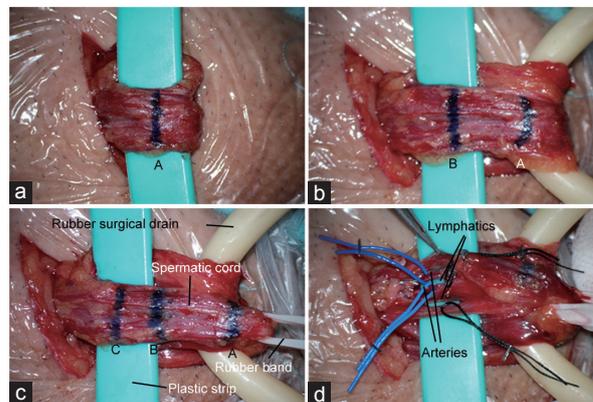


Figure 2: The spermatic cord double-traction approach elevates the surgical plane. (a) The conventional approach. The vas deferens and associated vasculature are isolated and preserved under a plastic strip. The surgery is performed on plane “A.” (b) The surgical plane “A” shifts up to “B” after spermatic cord traction using a rubber surgical drain. (c) The spermatic cord (without the vas deferens and associated vasculature) is retracted downward and fixed using a rubber band. The surgical plane “B” shifts up to “C.” (d) All of the internal spermatic veins are double-ligated with clips and then divided.

Table 2: The number of spermatic cord vessels

Characteristic	Left side	Right side
Veins ligated (n), mean±s.d. (range)	11.91±3.78 (4–24)	11.60±4.07 (3–24)
External spermatic vein	1.43±0.94 (0–8)	1.45±1.20 (0–8)
Gubernacular vein	1.28±1.11 (0–7)	1.12±0.80 (0–3)
Internal spermatic vein	9.21±3.25 (2–21)	9.03±3.48 (2–21)
Internal spermatic arteries (n), mean±s.d. (range)	1.97±0.98 (1–6)	2.05±1.07 (1–6)
1 (%)	34.61	36.36
2 (%)	43.71	31.82
3 (%)	13.99	24.24
4 (%)	3.85	3.03
5 or more (%)	3.15	3.03
Lymphatics (n), mean±s.d. (range)	3.89±1.97 (0–15)	3.89±2.10 (0–15)

s.d.: standard deviation

Table 3: Pre- and post-operative semen parameters in the oligoasthenospermia group

Characteristic (n=34)	Preoperation	Postoperation	P
Sperm concentration (×10 ⁶ ml ⁻¹)	21.75 (10.96, 38.25)	51.75 (17.56, 70.38)	0.0003
PR sperm number (×10 ⁶)	9.150 (1.95, 15.52)	25.33 (3.64, 82.08)	0.0001
Total sperm number (×10 ⁶)	49.65 (20.18, 89.57)	127.0 (42.41, 202.2)	0.0002
PR sperm ratio (%)	16.58 (3.63, 24.25)	34.88 (4.38, 45.56)	0.0003

Data are presented as median (P25, P75). P values were calculated with nonparametric tests. OAS: oligoasthenospermia; PR sperm: progressive sperm

Table 4: Patients' demographics and the response of the nonobstructive azoospermia patients to MSV-STVS

Patients characteristic	Yes, n (%)	No, n (%)
Sperm recovery in ejaculates	15 (12.3)	106 (87.7)
Get natural pregnancy (n=15)	5 (33.3)	10 (66.7)
Get successful ICSI (n=10)	4 (40.0)	6 (60.0)
Underwent micro-TESE	25 (20.7)	96 (79.3)
Sperm recovery in micro-TESE (n=25)	3 (12.0)	22 (88.0)
Get successful ICSI (n=3)	2 (66.7)	1 (33.3)

NOA: nonobstructive azoospermia; MSV-STVS: microsurgical subinguinal varicocelectomy and spermatic cord double-traction and varicose gubernacular and external vein stripping strategy; micro-TESE: microdissection testicular sperm extraction; ICSI: intracytoplasmic sperm injection

often densely adherent to veins at this location.⁴ The double-traction strategy in MSV-STVS avoids opening the external oblique aponeurosis but allows the operation at “proximal location,” which reduces tissue damage and accelerates recovery, and may have the benefit of a lower risk of arterial injury or missed venous ligation. Second, previous studies reported significantly higher antioxidant power and lower levels of markers of oxidative stress in sufficient veins compared with insufficient or varicose veins. The imbalance between oxidant and antioxidant production in varicose veins contributes to the pathological mechanism of varicocele.¹⁷ Stripping, which refers to the removal of varicose veins, eliminates the potential damage caused directly by varicose veins to the testis.

The MSV approach involves more veins compared with an inguinal approach,¹⁸ and MSV is more complex and technically challenging and requires microsurgical expertise.⁸ However, the double-traction strategy may provide sufficient access to ligate veins at the inguinal level. A previous study reported 12.9 internal spermatic veins and 0.9 external spermatic veins in average in the subinguinal plane.¹² Another study reported 11.1 internal spermatic veins and 5.4 external spermatic veins in average in the subinguinal plane, and 8.7 internal spermatic veins in average in the inguinal plane (data for the external veins not shown).¹³ Our data showed that the number of internal spermatic veins (left/right: 9.21/9.03 in average) was close to that in the inguinal plane but lower than that in the subinguinal plane. In addition, we identified more arteries and lymphatics than in a previous report (arteries: 2.0 vs 1.5, lymphatics: 3.9 vs 2.4, respectively).¹¹ It should be noted that the increase in the number of vessels is accompanied by a more complex microanatomy. Both of these factors may increase surgical difficulty, prolong the operation time, and increase the risk of potential complications intra- and post-operatively. While it is difficult to quantify the complexity of the microanatomy, we considered that the operation would benefit from the complexity of the microanatomy and the lower number of vessels. Although there is no supporting research, we speculate that the double-traction strategy would also be available for the inguinal approach.

Varicocelectomy with testicular delivery was first reported by Marc Goldstein in 1992.⁹ Testicular delivery provides direct visual access to all possible avenues of testicular venous drainage, including the gubernacular veins and internal and external spermatic veins.^{8–10} The scrotal collaterals are considered the main cause of recurrences.^{9,17} In our approach, the varicose external spermatic veins and gubernacular veins were stripped, followed by testicular delivery. This method was proposed based on the mechanisms of oxidative stress.¹⁷ Previous studies found that the levels of oxidative stress increased in both the testis and the varicose veins with varicocele; antioxidant levels were significantly lower in men with varicocele than in men without

varicocele.^{19–21} Preoperative total antioxidant capacity levels in patients with varicocele were lower than those in the controls but increased significantly postvaricocelectomy. The oxidative stress index and the total oxidant capacity were significantly higher in the spermatic vein compared with the median cubital vein and decreased to similar levels compared with controls, postoperatively. Total oxidant capacity in the peripheral circulation and the oxidative stress index in the internal spermatic vein may be useful indicators of improved sperm counts following varicocelectomy.²² Therefore, we postulated that not only elevated temperature and venous reflux but also the varicose veins themselves could damage the testis, and that stripping these veins would eliminate their adverse effects. In addition, to those severe varicoceles which could be visible to the eyes, the external spermatic veins or the gubernacular veins were supposed to be obviously present. Varicose veins still existed postoperatively if they are not stripped, annoying some patients. In contrast, stripping these veins achieved excellent postoperative cosmetic outcomes.

The effect of varicocelectomy in men with NOA was recently evaluated; however, the value of surgery in these patients remains controversial. The primary benefit of varicocelectomy in men with NOA is the possibility of producing motile sperm in the ejaculate. The rate of restored spermatogenesis after varicocelectomy is inconsistent, and the reported rates of sperm recovery range from 0% to 57%.^{23–26} In addition, sperm retrieval rates using micro-TESE were reportedly higher in varicocele-treated patients.⁵ A recent systematic review revealed that varicocele repair was associated with spontaneous pregnancies in 13.6% of patients' partners; and assisted pregnancies using fresh spermatozoa from ejaculate occurred in 18.9% of patients' partners in the group of men with sperm in postoperative ejaculates.⁵ The unassisted and assisted pregnancy rates in the current study appear to be higher than those in previous reports.⁵ Several factors may influence pregnancy rates, namely the sample size, age, and surgical technique. We postulated that sperm recovery and pregnancy may benefit from varicose veins stripping; however, to obtain more convincing data, the role of varicocelectomy in NOA should be evaluated with future controlled trials.

Varicocelectomy is effective for scrotal pain in the vast majority of patients.⁴ A previous study reported 237 patients undergoing MSV with testicular delivery, of which 203 patients (86%) experienced complete resolution of pain, and 218 patients (92%) reported significant improvement.²⁷ In the current study, the rate of complete resolution of scrotal pain (71.7%) was not as high as that in other studies; however, the proportion of men who obtained some degree of relief from scrotal pain (98.3%) was higher than that reported in previous studies. In other words, varicocele repair was successful in 98.3% of our patients, which was higher than previously reported.^{27,28} Patients' pre- and post-operative scrotal pain was self-reported and recorded by the surgeons, which introduced potential bias. Furthermore, pain relief may depend on the character of the pain and the grade of varicocele.^{4,29} We did not analyze data evaluating the character of patients' pain. Further studies are needed to explore which patients would most benefit from MSV-STVS.

Preserving the testicular artery and lymphatics is vital in MSV. Damage to the testicular arteries and lymphatics leads to testicular atrophy and necrosis, and hydrocele formation.^{6,8,9,17} In the present study, we successfully preserved the testicular artery and lymphatics; no patients developed testicular atrophy or hydrocele, postoperatively. However, one hematoma and two wound infections occurred during follow-up. The hematoma was secondary to the loss of a titanium clip on an external spermatic vein. Because titanium clips may damage the

veins when returning the testicle, silk ligatures are recommended for external or gubernacular veins. The wound infections resolved after antibiotic treatment, debridement, and wound dressing. The overall complication rate was similar to other reports,^{6,14} and no other severe complications occurred, suggesting that this approach is safe.

The main limitations of this study were the retrospective design and the lack of a control group treated with the standard surgical procedure. Furthermore, there may have been bias, especially given the small sample size and the number of patients lost to follow-up. The relationship between the character of patients' pain and their outcomes should also be explored in depth. A prospective, randomized study with a large sample size that compares outcomes following MSV-STVS and standard surgical procedures is needed to reach a more solid conclusion.

CONCLUSION

This study showed that completely removing varicose veins during MSV-STVS resulted in reliable sperm quality improvement for oligoasthenospermia and NOA patients, and pain relief for symptomatic varicocele with low complications. The technique is a safe and effective approach for varicocele treatment.

AUTHOR CONTRIBUTIONS

RHT and HXC performed the surgeries. RHT and LYZ wrote the manuscript. LYZ, CY, and PL collected and analyzed the clinical samples. YHH and ZW assisted with patients' follow-up. ELZ and CCY assisted with data analysis. ZL designed the experimental strategy and revised the manuscript. All authors read and approved the final manuscript.

COMPETING INTERESTS

All authors declare no competing interests.

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